City of Bloomington 3rd Street Median Report

August 2003

Prepared by

BLN Beam, Longest and Neff, LLC

INDEX

BLN Beam, Longest and Neff, LLC
Consulting Engineers and Land Surveyors
8126 Castleton Road
Indianapolis, IN 46250
317.849.5832
317.841.4280 fax
www.b-l-n.com

August 28, 2003

City of Bloomington
401 N. Morton Street
P.O. Box 100
Bloomington, IN 47402

ATTN: Mr. John Freeman,
Director of Public Works

RE: 3rd Street Median Report

Dear Mr. Freeman:

The attached study was completed to determine the best median treatment for 3rd Street. Two treatments that offer solutions for this situation include:

- Limited access road with a raised median, and
- Two –way left turn lane with a flush median.

The pros and cons of each treatment are discussed in our study. Factors that we focused on improving included safety, traffic flow and economic impacts of the area.

The conclusion that came out of our study is that a raised median would provide the most benefits to Bloomington.

After reviewing our study, if you would like any additional information please feel free to call me.

Very truly yours,

BEAM, LONGEST AND NEFF, L.L.C.

Robert D. Fisher, PE
Vice President

RDF/am/ce
Enclosure
xc: File # 9000

3rd Street Median Report

3rd Street in Bloomington is classified as a primary arterial. Currently, over 20,000 vehicles per day utilize 3rd Street. Within the next ten years it is anticipated that the traffic volume will increase to nearly 30,000 vehicles per day.

The challenge of relieving the traffic congestion is the work at hand. For this situation, two proven solutions include:

- Limited access road with a raised median, or
- Two-way left turn lane with a flush median.

3rd Street Median – Raised or Flush?

As illustrated in Figure 1, raised medians are an effective way to institute access management and keep traffic moving. Raised medians provide safety to the driver though channelization of traffic. Left turns can only be made where there is a break in the median. As a result, the through lanes carry traffic at a normal speed.

Figure 2 illustrates a two-way left turn lane (TWLTL). The green cars represent vehicles that are traveling normally while the red cars represent vehicles that have moved into the TWLTL in anticipation of making a turn. The red car must watch the opposing lanes of traffic for an opening. With traffic counts reaching over 1850 vehicles per hour (during peak hours), finding an opening will be a challenge.

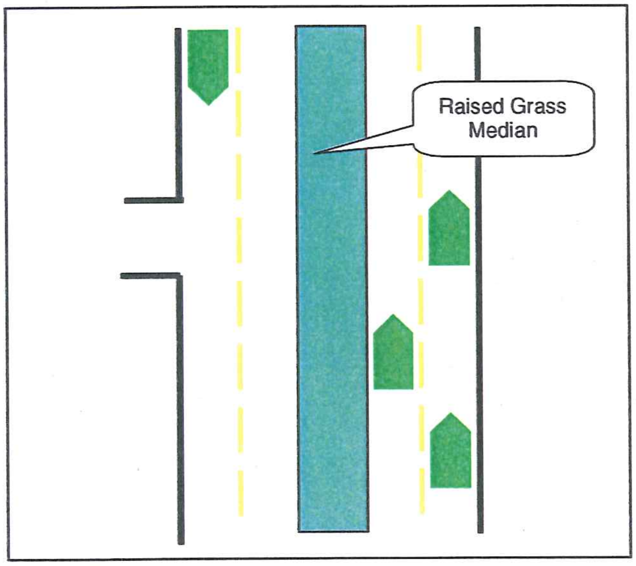


Figure 1. Roadway with a raised center median.

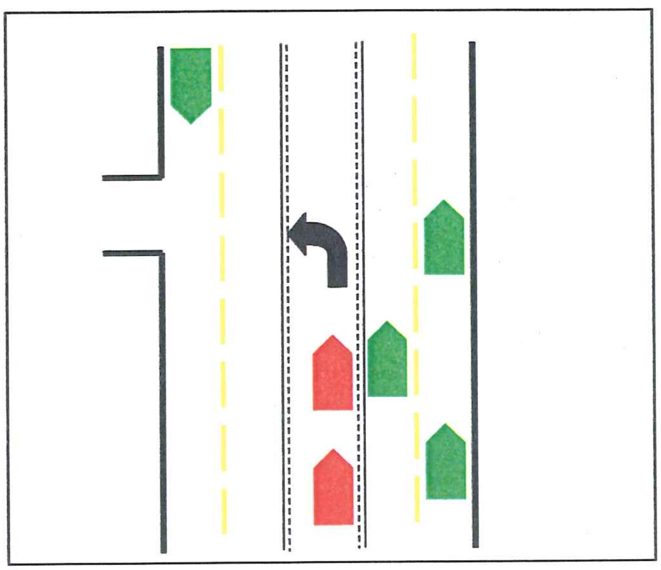


Figure 2. Vehicle making left turn with a flush median.

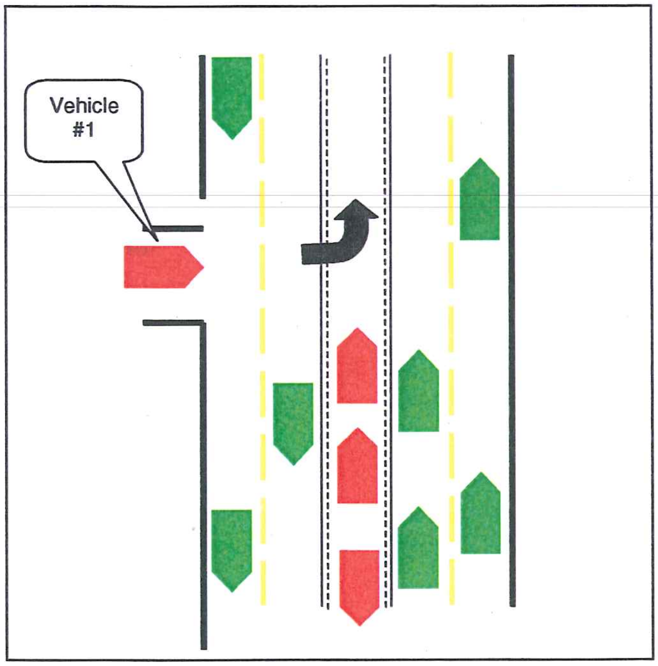


Figure 3. Vehicle turning left onto a major street.

Until now we have only talked about vehicles turning off 3rd Street onto a minor street or driveway. Another issue would be a vehicle trying to make a left turn from a minor street onto 3rd Street. This can sometimes be more of a challenge than turning *from* a major street, as the driver must watch for an opening in both the near lanes and the far lane they want to turn into. This dangerous situation is represented in Figure 3. This illustration has a TWLTL rather than a raised median. This option allows the driver to enter the TWLTL rather than directly into the traffic lane, however the driver must watch for vehicles pulling into the TWLTL. This is especially dangerous with multiple access points on primary arterials such as 3rd Street.

How Safe Is A Raised Median?

The National Cooperative Highway Research Program Report 3-52 gives some indication of the degree of safety obtained by comparing undivided roadway, raised medians, and the TWLTL. Other research has been done on the benefits of raised median roadways in urban areas which claim a 25 to 30 percent safety enhancement over undivided roadways.

Accident Rates Per 100 Million Vehicle Miles traveled.

Access Points per Mile	Undivided Roadway (Painted Centerline)	TWLTL	Raised Median	Accident Rate Reduction for Raised Median vs. TWLTL
Fewer than 20	3.8	3.4	2.9	-0.5
20 to 40	7.3	5.9	5.1	-0.8
40 to 60	9.4	7.4	6.5	-0.9
Over 60	10.6	9.2	8.2	-1

Source: National Cooperative Highway Research Program Report 3-52

According to the Indiana State Police accident reports, in 2001 there were at least 8 accidents on 3rd Street that a raised median could have prevented. These 8 accidents involved vehicles wanting to make left turns out of businesses and driveways or wanting to turn into them. Some were hit in the side by opposing traffic because they could not complete the turn and others were rear ended or caused a vehicle behind them to be rear-ended. Only accident reports that specifically mentioned a vehicle trying to make a left turn were counted. Also important to note is that there were more rear end accidents in the project area because of stopped traffic. This is mostly due to the intersections but a small amount may have been caused by left turning vehicles further ahead causing the traffic congestion. The total number of accidents reported in the project area in 2001 were 45. With the addition of raised medians we can expect a reduction in accidents of at least 18%. This reduction may be greater because this data represents current conditions, which are 2 lanes throughout most of the project area. We are increasing this to 4 lanes to accommodate traffic. If a TWLTL is utilized we can expect the number of left turn accidents to rise because of the extra lane of traffic that they need to cross.

What Are the Economic Impacts?

Businesses major complaint about raised medians is restricted customer access. Access will be restricted to vehicles traveling one way, however efforts have been made through the use of frontage roads and combined driveways to provide left turn access to most of the businesses along the street. Currently, the 3rd Street traffic situation is causing drivers to use 2nd Street in lieu of 3rd Street - bypassing the 3rd Street businesses altogether. The Center for Transportation Research and Education has preformed studies and determined the following key findings:

- More business owners surveyed in the project area reported a rise in sales or the same than declining sales.
- Only 19 percent of businesses reported having customer complaints with access.
- Over 80 percent of businesses reported they benefited from the project improvements.
- Businesses most likely to experience negative impacts were automotive related, for example gas stations and car washes.

The study can be found at http://www.ctre.iastate.edu/research/access/toolkit/8.pdf.

What Can We Conclude?

Although there are some drawbacks, such as restricted access, to adding a raised median the overall benefits far outweigh the drawbacks.

3rd Street is a primary arterial that would be safer and less congested with a raised median than with a TWLTL.


Example 1. TWLTL
96th Street on the North side of Indianapolis,
east of Keystone Avenue

Example 1A. TWLTL
96th Street, East of Allisonville Road


Example 2. Raised, landscaped median
82nd Street, east of Keystone Avenue

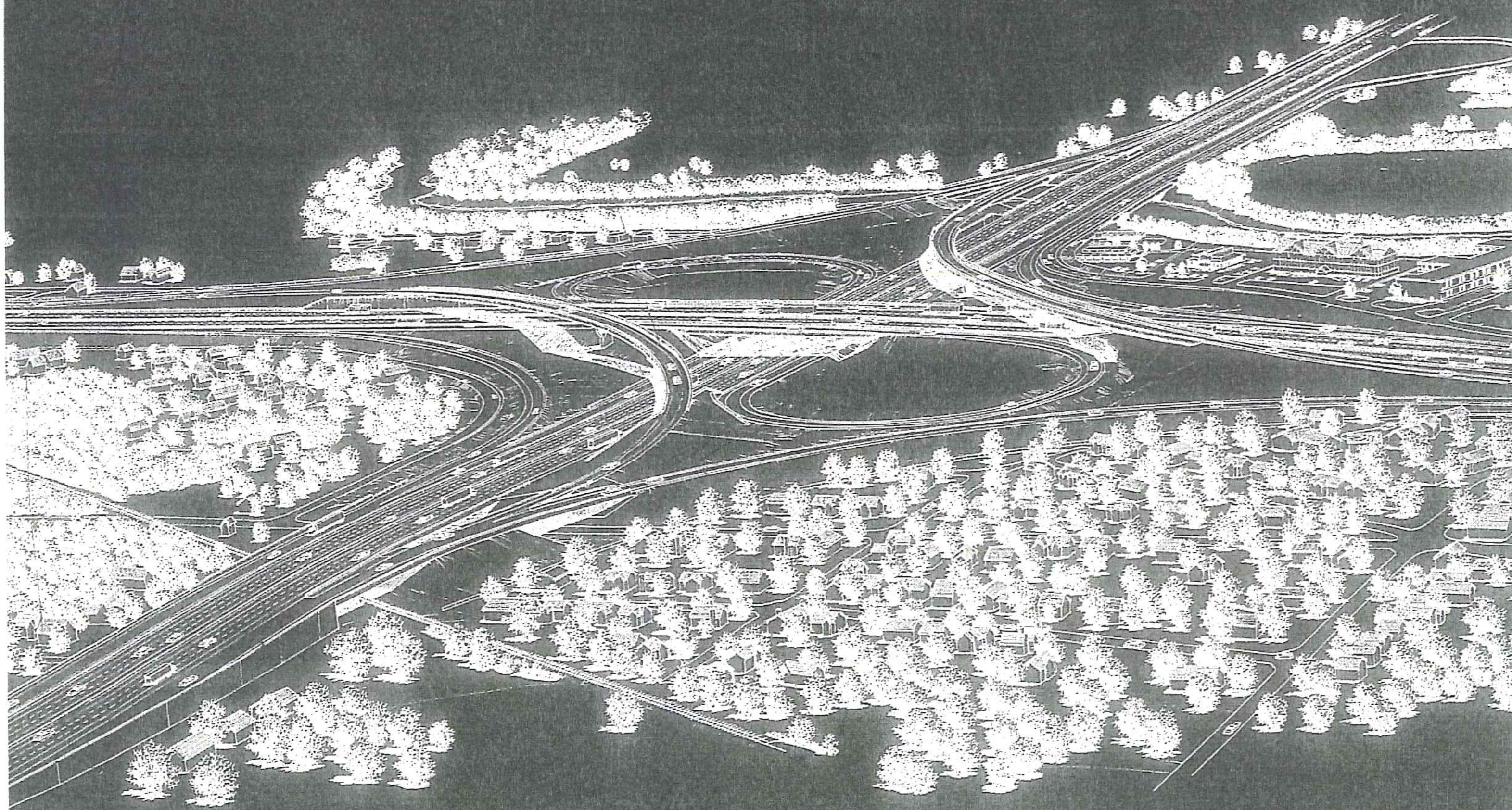
Example 2A. Raised, landscaped median
82nd Street, in Nora

ATTACHMENT 1

ATTACHMENT 1

DESIGN MANUAL

INDIANA DEPARTMENT OF TRANSPORTATION



PART V ROAD DESIGN

VOLUME I

45-2.0 MEDIANS

A median is desirable on many multi-lane highways. The principal functions of a median are:

1. to provide separation from opposing traffic,
2. to prevent undesirable turning movements,
3. to provide an area for deceleration and storage of left-turning vehicles,
4. to provide an area for storage of vehicles crossing the mainline at intersections,
5. to facilitate drainage collection,
6. to provide an area for snow storage,
7. to provide an open green space,
8. to provide a recovery area for out-of-control vehicles,
9. to provide a refuge area in case of emergencies,
10. to minimize headlight glare,
11. to provide an area for pedestrian refuge, and
12. to provide space for future lanes.

45-2.01 Median Widths

In general, the median should be as wide as can be used advantageously. The median width is measured from the edge of the two inside travel lanes and includes the left shoulders or curb offsets. The design width will depend on the functional class of the highway, type of median, availability of right-of-way, construction costs, maintenance considerations, the acceptable median slopes, the anticipated ultimate development of the facility, operations at crossing intersections and field conditions. In addition, the designer should consider the following to determine an appropriate median width:

1. Left Turns. The need for left-turn bays should be considered when selecting a median width.

2. Crossing Vehicles. A median should be approximately 8.0-m wide to safely allow a crossing passenger vehicle to stop between the two roadways. In areas where trucks are commonly present (e.g., truck stops), the median width should be increased to allow trucks to stop between roadways. The appropriate design vehicle for determining median width should be chosen based on the actual or anticipated vehicle mix of crossroad- and other traffic crossing the median.

3. Signalization. At signalized intersections, wide medians can lead to inefficient traffic operations and may increase crossing times.

4. Median Barriers. With narrow medians, a median barrier may be warranted. Therefore, the median will desirably be wide enough to eliminate the need for a barrier. See Section 49-4.05.

5. Operations. Several vehicular maneuvers at intersections are partially dependent on the median width. These include U-turns and turning maneuvers at median openings. The designer should evaluate the likely maneuvers at intersections and provide a median width that will accommodate the selected design vehicle. See Section 46-8.01 and Item #2 above.

6. Separation. From the driver's perspective, median widths of 12 m physically and psychologically separate him/her from the opposing traffic.

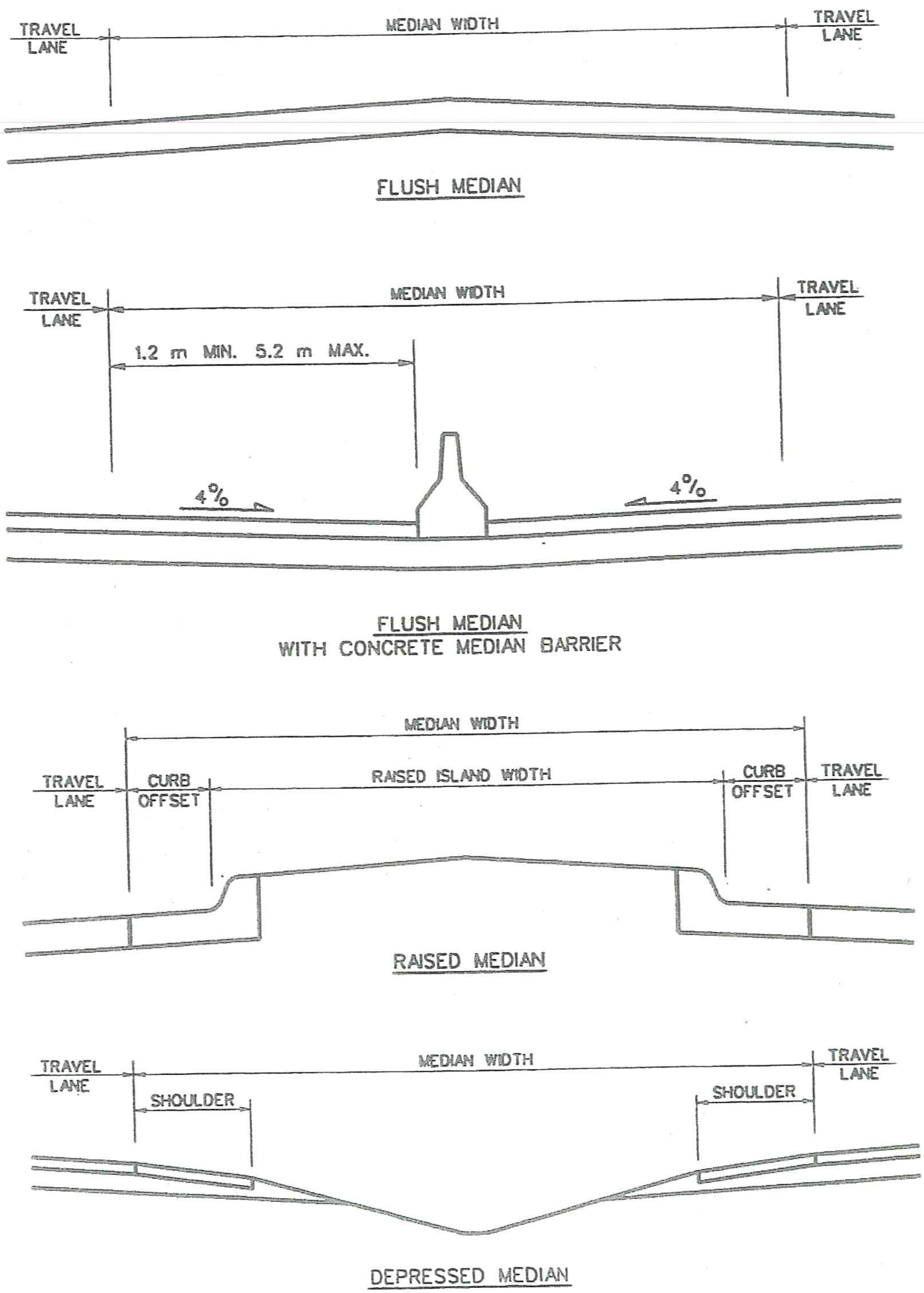
7. Uniformity. In general, a uniform median width is desirable. However, variable-width medians may be advantageous where right-of-way is restricted, at-grade intersections are widely spaced (800 m or more), or an independent alignment is practical.

8. Other Elements. The widths of the other roadway cross section elements should not normally be reduced to provide additional median width.

Section 45-8.0 include typical roadway cross section figures which also provide design details for medians. Chapter Fifty-three presents specific numerical criteria for median widths on new construction/reconstruction projects. On existing highways, retainage of the existing median width will be determined on a case-by-case basis.

45-2.02 Median Types

Figure 45-2A illustrates the basic median types — flush, flush with concrete median barriers, raised and depressed. The following sections provide additional information on these median types.



MEDIAN WIDTH DEFINITIONS

Figure 45-2A

45-2.02(01) Flush Medians

Flush medians are often used on urban highways and streets. A flush median should be slightly crowned to avoid ponding water in the median area. However, flush medians with concrete median barriers should be depressed to collect water within a closed drainage system.

The typical width for a flush median on an urban street ranges from 1.2 m to 4.8 m. If the median width is 4.8 m or less, the designer should consider using a continuous raised corrugated median or a slightly mounded median curb with 25 to 50 mm edge height. A corrugated type of median should generally be used where there is little or no anticipation that motorists will drive onto the median to make a left turn. The *INDOT Standard Drawings* provide additional details on the design of corrugated and mounded medians. To accommodate a left-turn lane, a flush median should be 4.2-m wide. This will allow a 3.6-m turn lane and a minimum 0.6-m separation between left-turning vehicles and the opposing traffic.

Two-way left-turn lanes (TWLTL) are also considered flush medians. Desirably, the roadway cross section with a flush median will allow ultimate development for a TWLTL. The tables in Chapters Fifty-three, Fifty-five and Fifty-six provide the criteria for TWLTL widths. Section 46-5.02 provides information on design details for TWLTL at intersections.

A flush median with a concrete median barrier may be used on urban freeways where the right-of-way does not allow for the use of a depressed median. For new construction and complete reconstruction projects, the minimum width of a flush median for an urban freeway is 8.0 m. This allows the use of two 3.6-m left shoulders and for the width of the concrete median barrier. On partial reconstruction projects, the minimum width may be the existing median width.

45-2.02(02) Raised Medians

Raised medians are often used on urban highways and streets to control access and left turns and to improve the capacity of the facility. Figure 45-2A illustrates a typical raised median.

When compared to flush medians, raised medians offer several advantages:

1. Mid-block left turns are controlled.
2. Left-turn channelization can be more effectively delineated if the median is wide enough.

3. A distinct location is available for traffic signs, signals, pedestrian refuge and snow storage.

4. The median edges are much more discernible during and after a snowfall.

5. Drainage collection may be improved.

6. Limited physical separation is available.

The disadvantages of raised medians when compared to flush medians are:

1. They are more expensive to construct and more difficult to maintain.

2. They may need greater widths to serve the same function (e.g., left-turn lanes at intersections) because of the raised island and offset between curb and travel lane.

3. Curbs may result in adverse vehicular behavior upon impact.

4. Prohibiting mid-block left turns may overload street intersections and may increase the number of U-turns.

5. They may complicate the drainage design.

6. Access for emergency vehicles is restricted.

If a raised median will be used, the designer should consider the following in the design of the median:

1. Design Speed. Because of the possible adverse effect curbs can have on a vehicular behavior if impacted, raised medians should only be used where the design speed is less than 80 km/h.

2. Curb Type. Either barrier or mountable curbs with edge height of 25 to 50mm or more may be used.

3. Appurtenances. If practical, the placement of appurtenances within the median is strongly discouraged (e.g., traffic signal poles, light standards).

4. Desirable Width. If practical, the width of a raised median should be sufficient to allow for the development of a channelized left-turn lane. This yields a 5.4-m median width assuming:

   a. a 3.6-m turn lane,
   b. a 0.6-m curb offset between the opposing through lane and raised island, and
   c. a minimum 1.2-m raised island.

5. Minimum Width. The recommended minimum width of a raised median should be 2.4 m. This assumes a minimum 1.2-m raised island with 0.6-m curb offsets on each side adjacent to the through travel lanes. In restricted locations, a continuous barrier curb may be offset 0.3 m and a mountable curb offset may be 0.0 m. Under these conditions, the minimum raised median width with barrier curbs is 1.8 m and 1.2 m with mountable curbs.

6. Raised Island (Paved). For raised islands up to 5.0-m wide, the island should typically be paved to reduce the maintenance requirements of the median.

7. Raised Island (Landscaped). For raised islands greater than 5.0 m, the area between the curbs is usually backfilled and landscaped. However, where there are numerous signs, bridge piers, etc., in the island, it may be more economical to pave the raised island to eliminate excessive hand mowing.

45-2.02(03) Depressed Medians

A depressed median is typically used where practical on freeways and other divided rural arterials. Depressed medians have better drainage and snow storage characteristics and, therefore, are preferred on major highways. In addition, they provide the driver with a greater sense of comfort and freedom of operation. In the design of a depressed median, the designer should consider the following:

1. Widths. Depressed medians should be as wide as practical to allow for the addition of future travel lanes on the inside while maintaining a sufficient median width. See Chapters Fifty-three and Fifty-four.

ATTACHMENT 2

5th Edition

TRAFFIC ENGINEERING HANDBOOK

INSTITUTE OF TRANSPORTATION ENGINEERS

CHAPTER 10
Access Management

Frank J. Koepke, P.E.
Principal
S/K Transportation Consultants, Inc.

Introduction

As our nation's road network becomes more congested and the volume of traffic accidents (crashes) climbs, the management of access—the location, spacing, and design of private and public intersections—has been identified as one of the most critical elements in roadway planning and design. Access management provides or manages access to land development while simultaneously preserving traffic safety, capacity and speed on the surrounding road system, thus addressing congestion, capacity loss, and accidents on the nation's roadways. It helps achieve the necessary balance between traffic movement and land use access by careful control of the location, type, and design of driveways and public intersections.

Modern access management requires the coordination of land use planning and development with transportation, and calls for land use controls that are keyed to highway design policies and transportation system goals and capabilities. Access management is a method of maintaining and transforming road environments into safe, accessible, and viable areas now and in the years ahead. It extends traffic engineering principles to the location, design, and operation of access points serving activities along the highway. Access management also evaluates the suitability of the site for given developments from an access standpoint at the same time that it identifies the need to maintain the utility of the roadway to serve through-traffic. Arterial streets, highways, and collector roads must serve both access and movement needs. These roads are where the major problems of driveway access and traffic congestion are found—where political pressures too often take precedence over engineering and planning decisions. The emphasis on access management must be placed on facilities such as these, to best preserve capacity and safety.

Why Should We Manage Access?

Our streets and highways are an important resource and represent a major public investment that should be preserved. This calls for their efficient operation—for effectively managing the access to and from land developments.

Traffic and transportation engineers have found many ways to improve flow along city streets, rural highways, and expressways over the past decades. They have shown how good roadway design and traffic operations can reduce delays, decrease accidents, and increase roadway capacities. They have shown how traffic signal systems, medians, turn lanes, and intersection channelization can work together to achieve these objectives.

However, traffic operational techniques alone do not offset the effects of poorly located or planned local street systems, or poorly designed access to adjacent properties. Nor can they always accommodate the large increases in traffic superimposed on existing roadways by major new developments that are placed without regard to the traffic-carrying capabilities of approach and/or surrounding roads.

Frequently, design criteria, driveway permit procedures, and traffic impact analysis requirements fall short of maintaining desired levels of services on the affected roadways. Too often, traffic impact studies are done separately for specific projects and fail to adequately consider the cumulative impact of nearby or closely spaced developments.

Because of the general lack of effective access control along our streets and highways, our communities are often faced with a chain of events that requires constant investment in roadway improvements and/or relocation. There is, in effect, a business growth and roadway improvement cycle in which increased business activity results in increased traffic, which leads to roadway improvements and, in turn, more business activity. Unfortunately, in many of today's communities, the ability to provide roadway improvements is restricted by limited funds, limited right-of-way and existing developments. In these instances access management may be the only available technique to improve the quality of traffic flow.

What If We Do Not Manage Access?

Simply said, the safety and efficiency of our transportation system will deteriorate if we do not manage access. Strip commercial development will be encouraged and the number of private driveways will proliferate. As the number of driveways increases, traffic congestion and the number of traffic accidents will increase.

Over time, and where feasible, roads will have to be widened to make up for capacity loss due to inefficient traffic operations. The incompatibility of servicing both land uses and traffic will become more severe and neighborhood streets will be used to bypass congested intersections and roadway sections. The large investment we have made in our roadway infrastructure will be squandered.

How Do We Manage Access?

Access management may be achieved by zoning controls, geometric design, access control guidelines, and purchasing access rights. Methods include: (1) classifying roadways based on criteria such as functional classification, (2) planning and maintaining a logical hierarchy of classified roadways, (3) defining allowable types and levels of access for each road class, (4) applying appropriate geometric design criteria and traffic engineering analysis to both the roadway and the allowable access, and (5) setting criteria for the spacing of signalized and unsignalized access points based on roadway class and speed. These criteria reflect the type of road, allowable access, type and size of activity centers, and the kind of driveways and their traffic volumes.

All state and local transportation agencies have basic statutory authority to control all aspects of highway design to protect public safety, health, and welfare. They have the right to regulate and acquire access rights along roadways. The acquisition of these rights may be expensive and time-consuming compared with access regulation, but the purchase of access rights is a stronger and longer-lasting solution. If access is regulated in advance of land development, the costs can be much less expensive. Some states and local governments have developed comprehensive access management codes that clearly define the kinds of access that may be permitted along various types of roadways.

In some ways, there is nothing new about access management that was not known in past decades. What is new is the decision to extend the concept of access control to arterial and collector roadways by committing to higher standards and by establishing the necessary legislative authority to implement them. What is also new is the growing recognition of access management as a rational way of coordinating transportation and land development thereby reducing congestion, improving safety, and enhancing the convenience of travel.

Access Management Policies and Regulations

A growing awareness that excessive or poorly designed access results in the functional obsolescence of major roadways is creating increased interest in access design and management. Most public agencies apply some form of access control to their streets and highways. These controls normally take the form of highway design standards, and driveway permit criteria. Traffic impact analyses are sometimes required to assure that any access problems that might result from proposed developments are identified and, to the extent reasonable, ameliorated.

Older access management policies more frequently set standards that addressed each specific point of access without looking at the systemwide impacts. Newer access management policies set system classification standards that address longitudinal operational impacts designed to preserve the functional integrity of the transportation system.

All states, counties, and cities provide full access control along freeways. Relatively few provide "partial" access control along expressways or arterials. Several states differentiate between limited access (i.e., freeways) and controlled access (i.e., expressways, arterials). However, broadly based access management programs are still the exception rather than the rule.

Local governments normally use land use controls and roadway improvement projects to manage access. Local zoning ordinances and subdivision regulations often specify site design, building setbacks, parking, and other elements that influence the type and location of the access by site-generated traffic.

State of the Art

The concept of "access management" has emerged steadily over the past decade to receive increasing attention from federal, state, county and local governments. Governmental policies vary greatly among states, counties, and cities, reflecting differing precedents, perspectives, and needs.

As part of National Cooperative Highway Research Program (NCHRP) project 3-38(7), *Access Management Guidelines for Activity Centers*, a "state-of-the-art" survey was conducted to establish a data base on which to build a series of access management guidelines.[1] Public agencies and private developers were canvassed for their current practices and policies, relevant codes and regulations, design standards and manuals, and perspectives on the viability and workability of various policies. Respondents provided a broad cross section of groups involved in access management.

The primary purpose of the survey was to ascertain access management practices, policies, and designs. The goals were threefold: (1) to obtain a reasonable representation by geographic location, city or county size, and types of access control; (2) to assess current programs, policies, and perspectives; and (3) to identify innovative approaches to access control and management.

An overview of those responding to the survey indicates that 71 percent of the governmental agencies have some type of formal access policy, and that 78 percent of these policies have been legislated into law. Seventy-three percent of the agencies stated that their current policies should be updated.

AASHTO does not have a specific access management policy but does state the following:

> The degree of access control required depends on the demands placed on the arterial. Because the rural arterial has greater importance than the local roads and collectors that usually serve all access needs, and cannot normally provide features associated with freeways, the arterial is most influenced by the use of access control. Provision of access control is vital to the concept of an arterial if it is to provide the service life for which it is designed.[2]

It also includes these statements:

> The failure to recognize and accommodate by suitable design each of the different trip stages of the movement hierarchy is a prominent cause of highway obsolescence. Conflicts and congestion occur at interfaces between public highways and private traffic-generating facilities when the functional transitions are inadequate. Examples are commercial driveways that lead directly from a relatively high-speed arterial into a parking aisle without intermediate provisions for transition deceleration and arterial distribution . . .[3]
>
> Driveways are, in effect, at-grade intersections and should be designed consistent with the intended use. The number of accidents is disproportionately higher at driveways than at other intersections; thus their design and location merit special consideration.[4]

[1] Transportation Research Board, *Access Management Guidelines for Activity Centers*, National Cooperative Highway Research Program Report 348 (Washington, D.C.: TRB, National Research Council, 1992).

[2] American Association of State Highway and Transportation Officials, *A Policy on Geometric Design of Highways and Streets* (Washington, D.C.: AASHTO, 1990), p. 521.

[3] Ibid., p. 2.

[4] Ibid., p. 841.

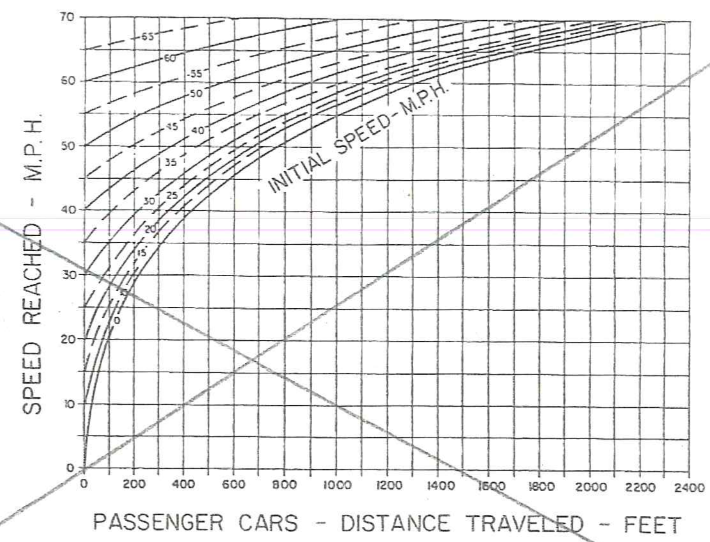


Figure 10–8 Acceleration of Passenger Cars, Level Conditions

Source: AASHTO, *A Policy on Geometric Design of Highways and Streets*, 1990.

Access Management Techniques

Many of the frequently used access management techniques that might be considered for implementation on roadways can be grouped into four general categories:

- reduce the number of conflict points,
- separate conflict points,
- remove turning vehicles from through-lanes, and
- improve roadway operations on rural two-lane highways

These techniques directly reduce the frequency of either basic or encroachment conflicts, or they reduce the area of conflict at some or all driveways and public street intersections with the highway by limiting or preventing certain kinds of maneuvers.

Conflicts occur when traffic is either diverging, merging, weaving, or crossing. Diverging, merging, or weaving maneuvers can be referred to as "minor" conflicts while the crossing maneuver has the potential for high-speed impacts and can be referred to as a "major" conflict. Diverging and merging conflicts can involve speed deferential between vehicles and are especially serious on high-speed, high-volume roadways.

A typical four-way intersection has 32 conflict points (Figure 10–9) and a typical three-way intersection has 9 conflict points (Figure 10–10). The installation of a nontraversable median to separate directional traffic and the provision of a lane or lanes only for right turns will have only two conflict points on either side of the median.

Limit the Number of Conflict Points

Several methods are listed below by which the number of conflict points can be reduced.

- **Installing a nontraversable median.** This technique eliminates all crossing and left- turn conflicts except at median openings. This application may be effective along roadway sections that have a narrow median and where the midblock accident experience is excessive. The provision of adequate left-turn or U-turn maneuvers at median openings must be considered.

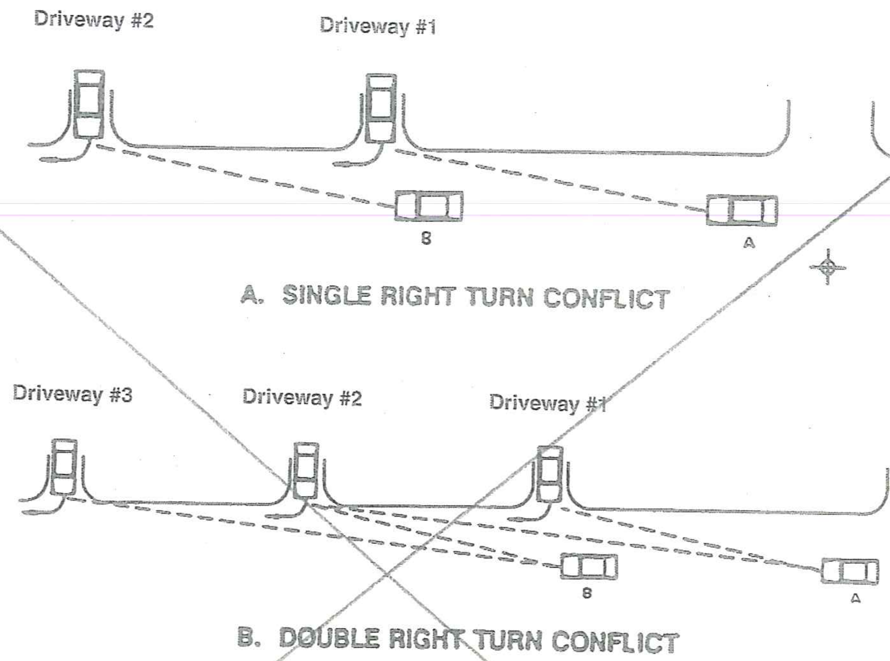


Figure 10–14 Right-Turn Conflicts

Source: NHI, *Access Management, Location, and Design*, NHI Course No. 15255, 1998.

However, if the application of this technique increases traffic volumes significantly at remaining driveways or if the restriction should have a significant impact on adjacent business activity, the denial or closing of an additional driveway should be further reviewed. On parcels with frontage on two streets, it is desirable to provide access only to the secondary street.

Vehicle service stations, which are almost always on corner lots, will want to have up to two driveways on each street. Only one driveway on the major road, located near the property line, is desirable. Depending on the classification of the intersecting street, one driveway is desirable, two are maximum. Care must be given to assure that vehicles can get to and from the gas pumps expeditiously and tanker trucks must be able to get to the storage tanks.

Consolidation of Existing Access

This technique encourages or requires adjacent property owners to construct joint-use driveways in lieu of separate driveways. The joint driveway will cause a reduction in driveway density along a roadway with the accompanying reduction in conflict points.

This technique is applicable on all major roadways with speeds greater than 55 km/h (35 mph). Driveway pairs with less than 50 vph using each driveway will be good candidates for this technique. It is recommended that both owners have property rights in a joint-use driveway. That is, the driveway should be located straddling the property line with each having a permanent easement on the other, or the driveway may be totally located on one property provided the other property users have legal access rights to the driveway. This practice will not enable either owner the opportunity to deny or restrict access to the neighboring property.

Various studies point to one consistent finding. An increase in the number of access points translates into increased delay, driver inconvenience, and higher accident rates. Thus, the greater the frequency of driveways and streets, the greater the number of accidents. The specific relationships, however, vary to reflect differences in road geometry (lane width and presence or absence of turn lanes and physical medians), operating speeds, and driveway and intersection traffic volumes.

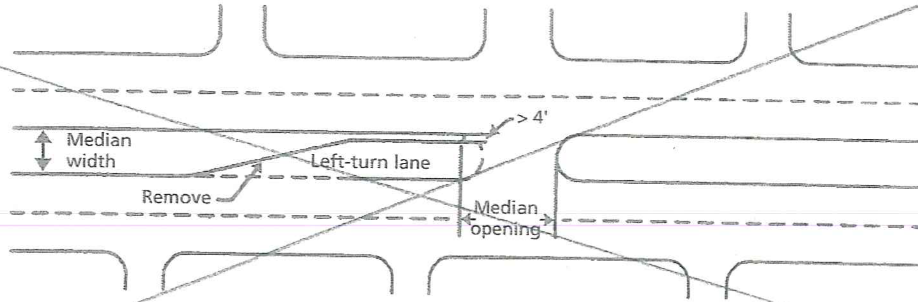


Figure 10–17 Left-Turn Deceleration Lane

Source: NHI, *Access Management, Location, and Design*, NHI Course No. 15255, 1991.

Alternating Left-Turn Lanes

An alternating left-turn lane will allow traffic from one direction to have a separate left-turn lane, then, after an adequate taper distance, the direction of the separate turn lane is reversed. Left-turn access to some driveways is prohibited because when the left-turn lane is available to one traffic direction, the opposing traffic should not attempt a left turn.

This technique is applicable on all types of highways where sufficient space is available for construction of median turn lanes. Median widths of 3.7 m (12 ft) or greater are desirable. The technique can be implemented on multi-lane roadways where the curb-to-curb width will accommodate an odd number of lanes. The necessary width can be obtained by removing parking or restriping the through-traffic lanes. This application is indicated on Figure 10–18.

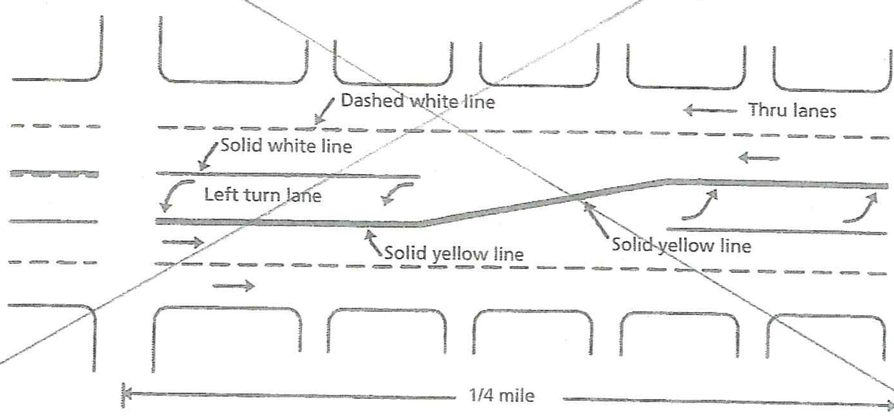


Figure 10–18 Alternating Left-Turn Lane

Source: NHI, *Access Management, Location, and Design*, NHI Course No. 15255, 1991.

Continuous Two-Way Left-Turn Lane

A two-way left-turn lane (TWLTL) is provided to remove left-turning vehicles from the through-lanes and store those vehicles in a median area until an acceptable gap in opposing traffic appears. The two-way left-turn lane completely shadows turning vehicles from both directions of through-lane traffic streams.

This technique is applicable on roadways with existing strip developments which have frequent but low volume driveways. Two moderate- to high-volume driveways should not be located in close proximity to each other. Continuous two-way left-turn lanes are compatible with the function of collective streets and some minor arterials serving commercial, industrial, and multi-functional residential areas.

Figure 10–19 illustrates the major design considerations applicable under this technique. Two-way left-turn lane widths of 3.7 to 4.3 m (12 to 14 ft) are desirable. However, existing conditions, particularly in urban setting may dictate lane-width modifications. Safety experience suggests TWLTLs should be limited to roadways having average daily traffic (ADT) of less than 24,000 vehicles.[17]

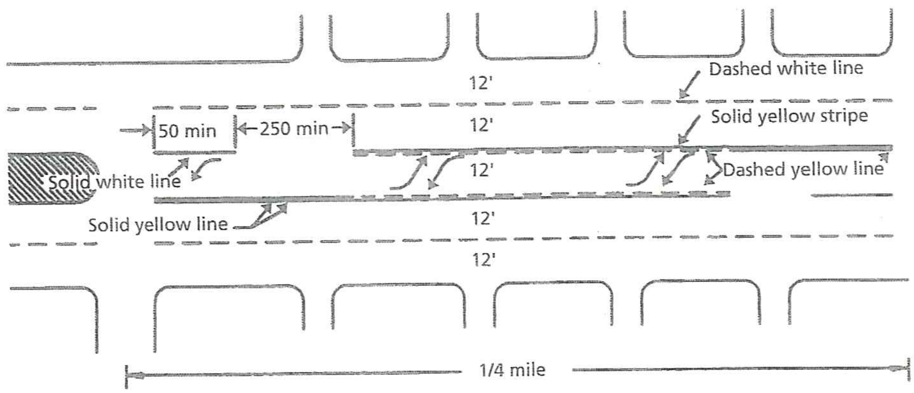


Figure 10–19 Continuous Two-Way Left-Turn Lane

Source: NHI, *Access Management, Location, and Design*, NHI Course No. 15255, 1991.

Isolated Left-Turn Lane

The functional objective of this technique is to remove turning vehicles or queues from the through-lanes at a major driveway. Improvements in left-turning operations result from the isolated median and deceleration lane which shadows and stores the left-turning vehicles.

Installing an isolated median left-turn lane is applicable on all undivided high speed roadways where an individual public road, or private driveway, has moderate to high volume left turns in one or both directions.

Suggested applications are:

Speed km/h (mph)	Minimum Left-Turn Volume (vpd)
55 (35)	200
70 (45)	150
85 (55)	100

AASHTO provides additional warrants for the installation of separate left-turn lanes that consider speed, left-turn volumes, advancing volume, and opposing volume.[18]

Figure 10–20 illustrates an isolated left-turn lane. Approach and departure taper ratios are a function of speed and should conform to AASHTO or local design standards.

[17] National Highway Institute, "Access Management, Location, and Design," participant notebook, course no. 15255 (Arlington, Va.: NHI, 1998).

[18] AASHTO, *A Policy on Geometric Design*, p. 791.

Median Openings

AASHTO states that a driveway should not be located within the functional boundary of an intersection.[19] Hence, the location and spacing of median openings should begin with establishing the minimum corner clearance. The functional limit is comprised of the deceleration distance plus storage. The minimum corner clearance for a left-turn ingress is approximately the sum of the functional limits of the two maneuvers. The minimum corner clearance for a left turn egress is slightly more than the functional length of the left turn at the major intersection.

The minimum spacing of other median openings is a function of the type of movements permitted as well as the functional limit of the maneuver(s). The minimum spacing of median openings for ingress movements for opposite directions is equal to the sum of the functional length (deceleration plus storage) of the two movements.

The minimum median spacing for ingress and egress to access on the same side of the roadway is the sum of the acceleration distance of the upstream egress opening plus the deceleration plus storage in the downstream ingress opening. The spacing of median openings for ingress and egress alternating on opposite sides of the roadway is the sum of the two acceleration distances.

U-Turn Maneuvers

If a nontraversable median exists, or is to be constructed, provisions have to be made to accommodate the redirected left turn. This can be accomplished by either a change in travel patterns or by providing sufficient space to accommodate the U-turn maneuver at a nearby intersection. AASHTO provides guidelines for median widths and pavement widths that accommodate U-turns. Additional research on this maneuver has been recommended.

Frontage Roads

Frontage or service roads provide increased access to developments and protect the main highway from frequent access demands. However, they complicate intersections along arterial and cross streets and, unless carefully designed and selectively applied in both new designs and in retrofit situations, they may prove counterproductive.

As an access control measure, frontage roads provide two main functions:

- They segregate local traffic from the high-speed through-lanes. Traffic can circulate among the various land developments without interfering with through-traffic.

- Frontage roads intercept the driveways serving the roadside properties and thereby reduce the number of conflict points on the main highway. The resulting spacing between the intersections with the main roadway facilitates the design of auxiliary lanes for deceleration and acceleration.

The intersection of frontage roads, especially continuous frontage roads, with the crossroad can result in overlapping intersections and produce a complex pattern of conflict points. Such intersections have very low capacities and the traffic volumes generated by commercial development on the frontage roads commonly result in severe congestion, long delays, and high accident experience. These problems can be minimized by incorporation of horizontal curves in the frontage road design to increase the separation between the intersections of the crossroad-frontage road and crossroad-main roadway as illustrated in Figure 10–22.

A separation of at least 75 m (250 ft) is desirable to reduce the interference of the frontage road intersection on the crossroad-main highway intersection. Such a separation also creates a buildable site suitable for a service station, fast food restaurant, or convenience store. A separation of 150 m (500 ft) will accommodate back-to-back left turn lanes between the main roadway and the frontage road.

[19] Ibid., p. 841.

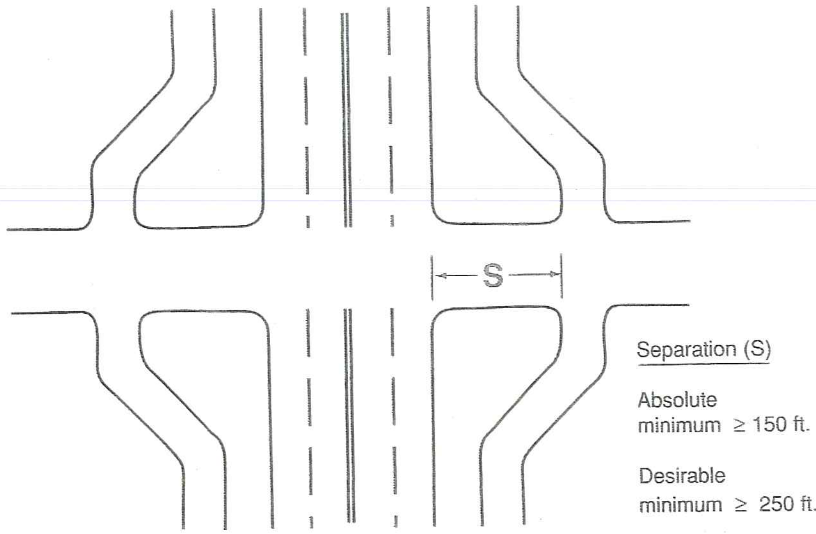


Figure 10–22 Frontage Road Alignment to Increase Intersection Spacing on Cross Road

Source: NHI, *Access Management, Location, and Design*, NHI Course No. 15255, 1991.

The following guidelines should be considered in installing arterial frontage roads in both new developments and retrofit situations.

- The separation of frontage roads at cross streets should be maximized to ensure sufficient storage for cross-road traffic between the frontage roads and the arterial. The desirable minimum separation should be 75 m (250 ft). This dimension is about the shortest acceptable length needed for placing signs and other traffic control devices.
- A minimum outer separation of 6 m (20 ft) should be used to provide space for pedestrian refuge and safe placement of traffic control devices and landscaping.
- The reverse frontage road concept can be applied in newly developing areas to create a network of controlled access arterials. Access along arterial streets is limited to specifically designated locations that fit the signal progression pattern. Arterial road intersections would be located at intervals of 800 to 1600 m (0.5 to 1 mi).
- Where major activity centers front along an arterial roadway, frontage roads should be incorporated into the site's internal circulation system or otherwise eliminated.
- Pedestrian and bicycle movements should use the frontage roads. Parking may be permitted where the frontage roads traverse residential areas.

An alternate to an adjacent frontage road is a reverse frontage road. This technique locates the frontage, or service road, one land parcel away from the arterial. All land access is provided by the service road. The road can be a separate entity or be part of the local street system. Land uses between the arterial and the "reverse frontage road" can range from residential to office to retail.

Residential properties can be buffered from arterial traffic, and parking for office or retail developments can be located behind the buildings (see Figure 10–23).

ATTACHMENT 3

CENTER FOR TRANSPORTATION RESEARCH
THE UNIVERSITY OF TEXAS AT AUSTIN

Center for Transportation Research
The University of Texas at Austin

Project Summary Report 0-1846-S
Project 0-1846: Development of Design Guidelines for the Provision of Median Access on Principal Arterials
Authors: Jillyn K. O'Shea, Thomas W. Rioux, Randy B. Machemehl
August 2001

PROJECT SUMMARY REPORT

DESIGN OF MEDIANS FOR PRINCIPAL ARTERIALS

WHAT WE DID ...

Public highways and streets have dual but competing roles: to provide property access and to move through traffic. Highway functional classification systems recognize the competition between access and flow, generally specifying that principal arterial streets primarily move traffic and secondarily provide access, while local streets primarily provide access and secondarily move traffic. Access provision is problematic for traffic flow because right turns, and especially left turns, into and out of driveways create traffic stream friction that often totally blocks through movements. Practical ways of controlling flow potential loss include limiting the number of property access driveways, restricting left-turn opportunities, and using good driveway geometric standards. Although the current criteria are appropriate, they lack the specificity needed by busy designers dealing with property owners and developers. This study provides specific guidance about safety, mobility, and economic impacts regarding:

1. Divided roadway and continuous center left-turn lane treatments,
2. Acceleration and deceleration lane design,
3. Raised and flush median treatments, and
4. Spacing between adjacent access points.

This process is applicable to four-lane, two-directional cross sections. The application method will follow a step-by-step instructional pattern that mimics the decision process that would be executed by a designer.

WHAT WE FOUND ...

Necessary Information

Information required to complete the application process includes:

- Directional 24-hour volume (two-lanes)
- Arterial speed
- Left-turn demand
- Driveway location(s) and distance(s) from the upstream intersection

This process assumes that the necessary right-of-way is available for left-turn treatment if it is required.

Task 1: Determining Whether Left-Turn Treatment is Required

The first step in median design, provided that the necessary right-of-way is available, is to determine whether left-turn treatment is required, given the roadway and adjacent driveway characteristics. There are several ways to accomplish this task.

1a: Safety Criteria

Several studies have determined that median treatment, regardless of type, is a safer alternative to no median treatment (Stover 1994). Therefore, if a disproportionate number of accidents occur in the vicinity of the driveway location as a result of left-turn-related maneuvers, then left-turn treatment is warranted without regard to operational criteria.

The Manual on Uniform Traffic Control Devices (MUTCD) uses five or more accidents within a 12-month period as a threshold for intersection signalization. Therefore, the four accidents per year criterion could appropriately be applied to an unsignalized inter section consisting of a driveway and a street.

If the left-turn-related accident rate is equivalent or exceeds 4/year, median treatment is warranted. If the safety criterion is satisfied, then proceed to Task 2; otherwise continue with 1b.

1b: Operational Criteria

The researchers developed three sets of decision charts to indicate if median treatment is required based on operational criteria. One chart set addresses excessive delay problems experienced by left turners.The delay threshold considered as excessive is average left-turn delays exceeding 35 seconds per vehicle (sec/veh). A second chart set relates operational problems incurred by the through-traffic stream. These charts identify conditions causing unacceptable through-traffic delay increases.

If a box is shaded, median treatment is warranted. If the operational criterion is satisfied, then proceed to Task 2.

1c: Calculation of Capacity and Delay

The designer may wish, however, to obtain more detail or may be unsure of the results given by the charts. In this situation, the decision can be made through a series of calculations that have been developed in this research effort. The first step is to determine the left-turn capacity of the driveway opening, which may be determined by using provided equations. Once the capacity of the driveway has been determined, the utility ratio (UR), which is the left-turn driveway demand divided by the capacity, is calculated. In cases where left-turn driveway demands have been unknown, the ITE Trip Generation Manual has been used to estimate left-turn driveway demands for selected land-use scenarios.

If the UR is equivalent to or exceeds 1, left-turn treatment is warranted. The designer should proceed to Task 2.

The next step is to predict the delay that will be experienced by left-turning vehicles or through traffic. This step is accomplished through the use of two sets of equations that were developed through the study. The designer can use either set of equations to determine if treatment is warranted or choose to compute both delays to identify a "worst case" scenario.

If $Delay_L$ or $Delay_T$ is equivalent to or exceeds 35 sec/veh, median treatment is warranted. The designer should proceed to Task 2.

Task 2: Raised Median or Flush Median Design

There are several criteria one should consider when selecting a raised median or a flush median design. Many attempts have been made to quantify the choice of median design, but there are many characteristics that are difficult to measure. Both types of designs have positive attributes and both have drawbacks.

Overwhelmingly, studies have favored raised medians over TWLTLs for safety considerations. However, all agree that some median treatment is better, in terms of both safety and operations, than the undivided cross section. Operationally, both designs are equivalent under low driveway density, low traffic volume, and moderate speed conditions. The literature states that raised medians are generally preferred when through volumes and driveway densities are high. TWLTLs are preferred under lighter through-volume conditions, though there is some debate surrounding the preferred driveway spacing and left-turn volume.

2a: Safety Considerations (Raised vs. Flush Median)

Flush median designs, continuous one- or two-way left-turn lanes (OWLTL, TWLTL), are not recommended where through-traffic speeds exceed 45 mph. A study of accident occurrence on continuous-turn lanes found accident rates only marginally higher compared to raised median sections. However, that study recommended limited continuous left-turn lane use under high-speed conditions because of the potentially catastrophic results of high-speed accidents.

If through-traffic speeds are greater than 45 mph, the designer should choose the "raised median" design.

As previously mentioned, research efforts have also shown that raised medians are safer at higher traffic volume conditions than TWLTLs. One criterion that has been used as a threshold value for choosing median designs is a 24-hour design volume of 24,000 vehicles.

If the 24-hour design volume is equivalent to or exceeds 24,000 vehicles, the designer should choose the "raised median" design.

2b: Operational Considerations

Flush median designs are generally not recommended along facilities that have significant traffic congestion. Since potential flow along arterials is limited by intersection capacity, congestion usually propagates upstream and downstream from intersections. One criterion for congestion identification is queues of more than ten vehicles in all intersection approach lanes or queues that cannot be dissipated during the green signal phase.

If intersection queues are greater than ten vehicles or queues are not dissipated during the signal green time, the designer should choose the "raised median" design.

If the median design is being developed for a new facility, or for any reason queues cannot be counted, congestion potential can be estimated using the ratio of demand to capacity. *The Highway Capacity Manual* is recommended as an easier way to estimate intersection capacity. If expected demand approaches calculated capacity, significant queues can be expected and conditions would likely exceed the threshold for significant congestion. Experience indicates, however, that a demand-to-capacity ratio exceeding 0.9 for a planned facility should be adequate justification for choosing a raised median design.

If intersection demand-to-capacity ratio exceeds 0.9, the designer should choose the "raised median" design. For the flush median design, proceed with tasks followed by an F and for raised median designs follow tasks marked with an R.

Task 3R: Determining the Necessity of Left-Turn Bays at Intersections

The flow of traffic on the network should take precedence over midblock turning movements. Therefore, once the general type of median design has been determined, it is important to establish the necessity of a left-turn bay at the intersection because it will affect the design of upstream median openings. This task can be accomplished by a number of means. Criteria for determining the requirement of left-turn bays have been outlined in numerous documents, such as the Highway Capacity Manual, Center for Transportation Research Report 258-1, and many state agency design manuals. The complete procedure described in the CTR 258 study is included in the 1846-1 report.

If left-turn demand is greater than the warranted left-turn volume Q_W, a left-turn bay is required at the intersection. The designer should proceed to the next task. Otherwise skip to task 5R.

Task 4R: Calculating the Length of the Intersection Left-Turn Bay

If a left-turn bay is necessary at an adjacent intersection, then it is important to size the bay before proceeding with median design, as this will directly impact driveway openings and placement along the roadway. Once again, this procedure has been well documented in other research efforts. The procedure that was developed in Research Report 258-1 from the Center for Transportation Research at The University of Texas at Austin is included in the complete 1846 report.

Task 5R: Assessment of Midblock Opening

In determining the location of a midblock opening, the designer must first ensure that the proposed opening will not infringe on the left-turn bay that has been established for the intersection. The placement of a median opening is infeasible if the proposed median location encroaches on the intersection left-turn bay. Provided that the median opening is viable, the operational characteristics of the driveway can be examined. There are three criteria to consider: the delay incurred by the left-turning vehicle, the storage area, and the distance between the intersection and other median openings.

Task 5Ra: Delay to the Left-Turner

Theoretically, if a left-turner waits for a traffic-stream gap in a bay or storage lane, then operationally there is no reduction in the level of service to the network through traffic if the vehicle driver waits indefinitely to complete his/her maneuver. Realistically, however, the driver will become impatient after a period of time and risk an accident by choosing a gap of insufficient size. The researchers developed a series of decision charts based on delays incurred by the left turner. These charts describe conditions under which unacceptable levels of delay are experienced.

If box is shaded, the designer should not provide a median opening; left-turn delays will likely exceed 96 seconds/vehicle.

If the designer is unsatisfied with the results of the charts because roadway conditions require interpolation between shaded and unshaded boxes, then he or she may calculate the left-turn delay with equations that were also developed.

If $Delay_L$ equals or exceeds 96 sec/veh, the designer should not provide a median opening.

Task 5Rb: Storage Area or Bay Length

Adequate procedures for determining the length of storage for the medians are similar to those used in determining the left-turn bay length at the intersection. The pocket length should be sized according to the entrance speed and to the ability of a vehicle to come to a stop before reaching the end of the queue. If the left-turn demand is unknown, estimates based on the *ITE Trip Generation Manual* are provided. See Task 4R for instructions on proper left-turn bay sizing.

Task 5Rc: Distance to the Intersection or Additional Median Opening

No median opening should be allowed to interfere with the functional area of another median opening or intersection left-turn bay. The functional area is defined as the distance required for channelization markings, queuing, and storage of vehicles wishing to complete a left-turn maneuver. Additionally, median openings should be prohibited in locations where a queue from an adjacent intersection would habitually form across the opening. The Florida DOT has defined a classification system of its roadways that is based on function. Using these access classes, the Florida engineers have set the following minimum median opening spacing criteria for arterials with both directional and full movements.

Task 5F: (OWLTL or TWLTL) Choosing One-Way or Two-Way Left-Turn Lanes

Few studies have been conducted concerning the choice between OWLTL and TWLTL. A TWLTL is generally chosen in areas of strip commercial development. An OWLTL is more beneficial at major intersections having high left-turn demand or where there are driveways on only one side of the street.

THE RESEARCHERS RECOMMEND ...

This document summarizes a process that can be used by the practitioner to design median treatments for a four-lane, bi-directional arterial roadway. The tasks required to complete this process are described with supporting information.

For More Details ...

Research Supervisor: Dr. Randy Machemehl, P.E., phone: (512) 232-3107, email: rbm@mail.utexas.edu

TxDOT Project Director: Gustavo Lopez, P.E., Pharr District Office, phone: (956) 702-6159, email: glopez@dot.state.tx.us

The research is documented in the following reports:
Report 1846-1, *Design Guidelines for Provision of Median Access on Principal Arteries*, Draft February 2001

To obtain copies of the report, contact: CTR Library, Center for Transportation Research, phone: 512/232-3138, email: ctrlib@uts.cc.utexas.edu.

TXDOT IMPLEMENTATION STATUS
AUGUST 2001

The research developed new design guideline criteria to aid in the decision making process for selecting the proper median type for principal arterials.

The research resulted in a decision tree and implementation guide for the application of various types of median design and geometric guidelines for median openings. The median design decision tree is being incorporated into TxDOT geometric design practices.

For more information, please contact Bill Knowles, P.E., Research and Technology Implementation Office (512) 465-7648 or email: wknowle@dot.state.tx.us.

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